# Hidden Figures: Eminent Women of Applied Mathematics

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# Hidden Figures: The Movie


Credits: www.nerdly.co.uk

# Hidden Figures: Lead Characters

Mary Jackson

Katherine Johnson

Dorothy Vaughan

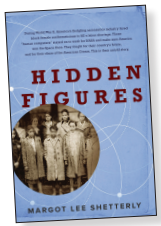
Credits: www.nasa.gov/modernfigures

# Hidden Figures: Trailer

Movie Trailer ▸ Link

https://www.youtube.com/watch?v=RK8xHq6dfAo

# Hidden Figures: Learning More




## Hidden Figures Light Up Screen

### Black Women Who Helped America Win the Space Race

JENNA P. CARPENTER

During World War II, the National Advisory Committee for Aeronautics (NACA) used computers to make advancements in aeronautics. Later, during the Cold War, NACA's successor, NASA, turned these computers to the task of tackling the challenges of putting Americans in space. At first this may not sound surprising, but in this era the word *computers* referred to people, not electronic or digital machines. Moreover, it was nearly lost to history that these computers were largely women, some of whom were African American.

In *Hidden Figures: The Untold Story of the Black Women Mathematicians Who Helped Win the Space Race* (William Morrow, 2016), Margot Lee Shetterly tells the surprising story of the West Computers division—a segregated team of black female mathematicians who worked on largely by-hand computations at Langley Memorial Aeronautical Laboratory during the mid-20th century.

Shortly after the book appeared, Fox 2000 released a movie version of *Hidden Figures* with an all-star cast. Last summer I chatted with Shetterly and Fox 2000 president Elizabeth Gabler about their roles in bringing this intriguing story to light.

Shetterly's and Gabler's comments have been edited for clarity.


Aran Shetterly
Margot Lee Shetterly.

#### An Unlikely Author

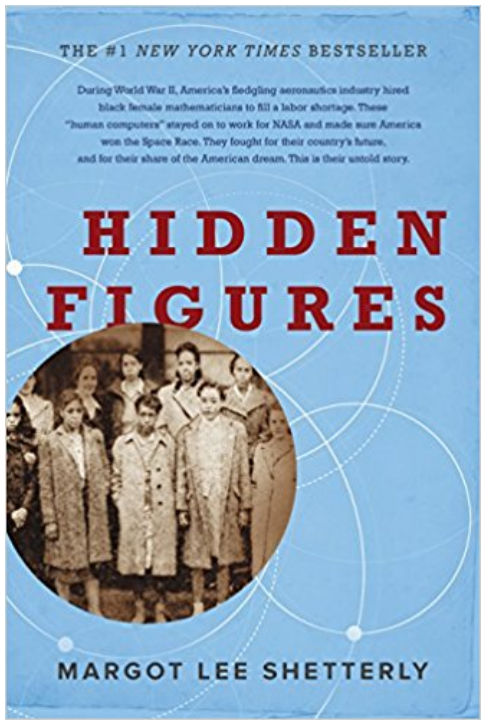
Given that Shetterly had never written a book before and was not a STEM (science, technology, engineering, and mathematics) professional, I wondered what led her to write a book about a story that was so complex in both its content (mathematics, aeronautics, and space flight) and setting (the time leading up to and during the civil rights movement).

She pointed out that she grew up in Hampton, Virginia, home to Langley, where she had visited her father, an internationally recognized climate scientist, many times. And she knew some of the women she would later write about as residents of her hometown.

In the foreword, Shetterly writes, "Growing up in Hampton, the face of science was brown like mine. . . . I knew so many African-Americans working in science, math, and engineering that I thought that's just what black folks did. . . . I thought these stories were normal. It was my husband's reaction to hearing this story for the first time that helped me see it with fresh eyes and realize that it is unusual and interesting. . . . [It] spurred me to explore the story and learn more."

Shetterly began by talking to her former Sunday school teacher, Katherine G. Johnson, the NASA mathematician who worked on problems associated with getting NASA's astronauts into space. She told me that from there, "it got more and more interesting. I found out that there were so many women involved. Everyone






Math Horizons, February 2017

Credits: www.maa.org/mathhorizons; amazon.com

# Membership/Fellowship in Learned Societies

- US National Academy of Sciences (NAS)
- American Association for the Advancement of Science (AAAS)
- American Academy of Arts and Sciences (AAAS)
- American Mathematical Society (AMS)
- Society for Industrial and Applied Mathematics (SIAM)
- Fellows of the Society for Mathematical Biology (SMB)

# US National Academy of Sciences

- Current members annually elect new members, based on their distinguished and continuing achievements in original scientific research, for life.
- Approximately 2500 members; approximately 200 of these have won a Nobel Prize.
- Founded in 1863.
  - 1924: first woman elected (Florence R. Sabin; medical scientist)
  - 1965: first African-American elected (David Blackwell; statistician)
  - 2013: first openly transgender scientist elected (Ben Barres, born as Barbara Barres; neurobiologist)
  - 2016: first female president (Marcia McNutt; geophysicist)

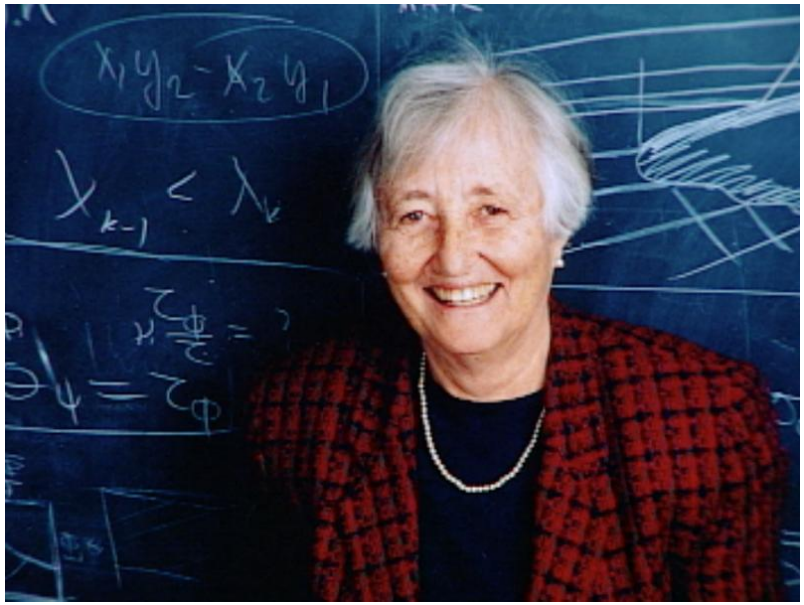
Credits: Wikipedia

# US National Academy of Sciences: Membership

| | **Mathematics** alive / deceased | **Applied Mathematical Sciences** alive / deceased |
|---|---|---|
| Total | 104 / 79 | 58 / 31 |
| Female | 4 / 4 | 7 / 2 |
| | Sun-Yung Alice Chang<br>Ingrid Daubechies<br>Dusa McDuff<br>Maryam Mirzakhani<br>Marina Ratner<br>Julia Robinson<br>Tracy Y. Thomas<br>Karen K. Uhlenbeck | Marsha J. Berger<br>Gertrude M. Cox<br>Guinevere Kauffmann<br>Cathleen Synge Morawetz<br>Elizabeth A. Thompson<br>Grace Wahba<br>Ruth J. Williams<br>Margaret H. Wright<br>Bin Yu |
| | | Nancy Jane Kopell |

Credits: www.nasonline.org

# Cathleen Synge Morawetz (1923 – 2017)



Applied Mathematician

Known for her work on the scattering of waves, and the mathematics of transonic flow

Credits: www.nationalmedals.org; The Door in the Dream, by Elga Wasserman

# Cathleen Morawetz: Journey in Mathematics

- Born in Toronto, to Irish parents.
- Father was a distinguished mathematician; Director of Institute for Advanced Studies in Ireland before moving to Canada; Mother had mathematical training as well.
- 1945: Bachelor's in Mathematics, University of Toronto
- 1946: Master's in Mathematics, MIT
- 1946: Hired by Richard Courant at NYU, editing his book "Supersonic Flow and Shock Waves"
- 1951: Ph.D. in Applied Mathematics, NYU
- 1952–1957: Research position, NYU
- 1957–1991: Professor, Courant Institute, NYU

Credits: www.simonsfoundation.org/2012/12/20/cathleen-morawetz/; The Door in the Dream, by Elga Wasserman

# Cathleen Morawetz: Work and Legacy I

Transonic Flow:

- When an airplane flies more slowly than the speed of sound, it is said to be flying subsonically. When it flies faster than the speed of sound, it flies supersonically. Transonic flow refers to the behaviour of air when the airplane approaches the speed of sound, and troublesome shock waves (supersonic booms) occur.
- Engineers had designed wings to minimize shocks. Could shocks be eliminated entirely?
- Cathleen Morawetz proved that shocks cannot be eliminated entirely: airfoils with smooth flow do exist, but the smooth flow is **unstable** – any perturbation destroys the smooth flow, inducing a shock wave or boom.

Credits: www.simonsfoundation.org/2012/12/20/cathleen-morawetz/

# Cathleen Morawetz: Work and Legacy II

Wave Scattering:

- Mathematical analyses of high-frequency vibrational waves can be used by geologists to locate the presence of oil deposits.
- Similar analyses form the basis of ultrasound techniques used in medicine to visualize internal organs and the fetus in utero.
- Morawetz inequalities and Morawetz estimates are plentiful, and show up in procedures to find solutions to a large class of dispersive equations, such as those that describe the propagation of light.

Credits: The Door in the Dream, by Elga Wasserman

# Cathleen Morawetz: Work and Legacy III

YouTube Video ▸ Link
https://www.youtube.com/watch?v=vcGgH1THPrE

Simons Foundation profile ▸ Link
https://www.simonsfoundation.org/2012/12/20/cathleen-morawetz/

# Cathleen Morawetz: Personal Life

- Four children
- Ten grandchildren
- Three great-grandchildren

In an interview with the journal Science in 1979, Morawetz recalled that when her children were young, people often asked whether she worried about them while she was at work.

Her reply:

> *No, I'm much more likely to worry about a theorem when I'm with my children.*

Credits: NY Times, August 11, 2017

# Nancy Jane Kopell (1942 – )

Applied Mathematician

Specializes in mathematical neuroscience, with a focus on the dynamics of networks of neurons

Credits: www.bu.edu/today/2011/will-math-help-cure-brain-diseases-nancy-kopell-says-maybe/

# Nancy Kopell: Journey in Mathematics

- Born in New York City
- Father worked as an accountant; mother and older sister studied mathematics
- 1963: B.S. in Mathematics, Cornell University
- 1967: Ph.D. in Mathematics, UC Berkeley
- 1967–1969: C.L.E. Moore Instructor, MIT
- 1969–1986: Northeastern University
- 1986: Boston University

Credits: Wikipedia; The Door in the Dream, by Elga Wasserman

# Nancy Kopell: Work and Legacy I

Belousov-Zhabotinsky Reaction:

- First example of a nonlinear chemical oscillator; excitable (under influence of stimuli, spatiotemporal patterns develop in what would otherwise be a perfectly quiescent medium).
- Studied solution behaviour of a system of reaction-diffusion equations describing the chemical reaction; able to predict patterns.
- Studying this system set Nancy Kopell on the path of thinking about what the essential elements are that lead to spatiotemporal structure.

Credits: Trends in Neurosciences. 36 (6): 313314

# Nancy Kopell: Work and Legacy II

Coupled Oscillators; Networks of Oscillators:

- Studies synchronization and phase-locking of coupled oscillators, both in abstract settings and in the context of brain rhythms.
- Studies the physiological origins of various brain rhythms, in the neocortex, hippocampus, thalamus, and striatum.
- Investigates how changes in rhythms in Parkinson's disease and schizophrenia lead to abnormal coordination and cognition.

Credits: Trends in Neurosciences. 36 (6): 313314

# Nancy Kopell: Work and Legacy III

YouTube Video ▸ Link
https://www.youtube.com/watch?v=II0IIZKMtOc

# Nancy Kopell: On Mentoring

Nancy Kopell credits several mentors with being key factors in her career.
Smale's mentoring was key to her success at Berkeley.
Her first collaborator at MIT, Lou Howard, helped her reinvent herself as an applied mathematician.

> *Later, it was my husband-to-be who provided the encouragement I needed to change fields from my thesis work to an area that was not populated enough even to be called a field. I cannot imagine that I could have survived the early years of my career psychologically or intellectually with the help of these two people. Mentoring played a key role in my career.*

Credits: The Door in the Dream, by Elga Wasserman

# Margaret H. Wright (1944 – )

Mathematician and Computer Scientist

Specializes in optimization, linear algebra, numerical analysis, scientific computation, and scientific and engineering applications

Credits: cs.nyu.edu/mhw/

# Margaret Wright: Journey in Mathematics

- Parents both medical doctors
- Born in California; grew up in Arizona
- 1964: B.S. in Mathematics, Stanford
- 1965: M.S. in Computer Science, Stanford
- 1965-1971: Scientific programmer, GTE Sylvania
- 1976: Ph.D. in Computer Science, Stanford
- 1976–1988: Research Associate, Stanford
- 1988–2000: Computing Sciences Research Center, Bell Laboratories
- 2001: Silver Professor of Computer Science and Mathematics, Courant Institute, NYU

Margaret Wright was the first female president of the Society for Industrial and Applied Mathematics (SIAM), 1995–1996.

Credits: Wikipedia; www.simonsfoundation.org/2014/02/12/margaret-wright/

*I've been on a number of panels about women in math, women in computer science, and with every panel, the more senior women have said, 'Well, I have a nontraditional career path' and 'I didn't plan to do this' and 'When I started out I didn't know what to do.' And that's really true of me. When I meet young women now – young people – I give them advice about if you want to do this, then it's a good idea to do that, dat-da-dat-da-da. I didn't have any of that, any of it. So nothing is optimal in my career. In fact, when you look at it, it's sort of a miracle that I've ended up at the Courant Institute, really.*

Credits: www.simonsfoundation.org/2014/02/12/margaret-wright/

# Margaret Wright: Work and Legacy I

Margaret Wright's PhD research was based on barrier methods for optimization problems with nonlinear constraints.

- In the 1970's, barrier methods were in decline, in large part because of concerns about provable ill-conditioning, meaning that a tiny change in the problem could lead to a huge change in the exact solution.
- Margaret Wright devised a new family of methods that avoided the ill-conditioning.
- Manuscript on her work was rejected without even being refereed.

Credits: www.simonsfoundation.org/2014/02/12/margaret-wright/

# Margaret Wright: Work and Legacy II

1979: "A Soviet Discovery Rocks World of Mathematics", front-page news in the NY Times

- Soviets announce polynomial-time "ellipsoid" solution method for linear programming problems.
- Margaret Wright and collaborators show that the ellipsoid method almost always is much slower than the Simplex method.

Credits: www.simonsfoundation.org/2014/02/12/margaret-wright/

# Margaret Wright: Work and Legacy III

1984: "Breakthrough in Problem Solving",
front-page news in the NY Times

- Karmarkar of AT&T Bell Labs announced his invention of a polynomial-time algorithm for linear programming problems.
- During visit to Stanford, Karmarkar wrote down equations that were strongly reminiscent of the equations that would arise if a barrier method were applied to linear programming.
- Margaret Wright and her collaborators investigated further, and showed that under certain conditions Karmarkar's method was formally equivalent to a barrier method.

Credits: www.simonsfoundation.org/2014/02/12/margaret-wright/

# Margaret Wright: Work and Legacy IV

Simons Foundation profile ▸ Link
https://www.simonsfoundation.org/2014/02/12/margaret-wright/

# Margaret Wright: Diplomatic Activist

With Julia Hirschberg, she contributed to a set of advances made for women's status at Bell Labs: increases in women's salaries, promotion opportunities for women, etc.

Julia Hirschberg:

> *Margaret's a real leader. You absolutely trust her – her judgment, fairness and humanity. With Margaret you feel there is no hidden agenda, no personal agenda. She is an extremely honest and effective person.*

> *One of our [self-defense] instructors said that Margaret was particularly 'ruthless' – he meant it as a compliment, of course! Margaret combines an amazing tactfulness with an uncompromising commitment to doing the right thing.*

Credits: www.simonsfoundation.org/2014/02/12/margaret-wright/

# Concluding Thoughts

Why did I choose to speak about Cathleen Morawetz, Nancy Kopell, and Margaret Wright?

- Cathleen Morawetz: President of the American Mathematical Society 1995–1996
- Nancy Kopell: MacArthur Fellow 1990–1995; Elected to the NAS 1996; Elected to the AAAS 1996
- Margaret Wright: President of the Society for Industrial and Applied Mathematics 1995–1996